EDUCATION FOR THE SUSTAINABLE DEVELOPMENT THROUGH FUZZY LOGIC

Raquel Caro[1], Adela Salvador[2], Alfonso Garmendia[3], Raúl Martín[4]

[1]Universidad Pontificia Comillas-ETS-ICAI (SPAIN)
[2]Universidad Politécnica de Madrid-ETSI Caminos (SPAIN)
[3]Universidad Politécnica de Valencia-Instituto Agroforestal Mediterráneo (SPAIN)
[4]Universidad Complutense de Madrid-Facultad de informática (SPAIN)
rcaro@upcomillas.es, ma09@caminos.upm.es, algarsal@upvnet.upv.es, rmb2000@gmail.com

Abstract

The decision of the General Assembly of the United Nations to establish the period 2005-14 as the Decade of Education for Sustainable Development offers university groups committed to environmental education an opportunity to strengthen its teaching and research efforts, consolidating a model education whose main elements are in full harmony with the paradigm of sustainable development.

The University, for its genuine social function, has the mission to contribute to the construction of progressively more sustainable societies, ie, more human, solidarity, equitable and fair. In this respect, and from the standpoint of curriculum design in engineering degrees, this work provides a new approach to introduce students to the project evaluation criteria, with special emphasis on the social impacts, environmental and economic development in the same local, regional or national level through the definition and identification of sustainability indicators evaluated using Fuzzy Logic. The use of this tool is justified by the management of incomplete, inaccurate and inconsistent information.

This paper shows that there are benefits to society of the teaching evaluation of sustainable projects, the need for research on a model that allows using Fuzzy Logic to help make decisions on certain aspects of the social, economic or environmental impacts of a project and it is a simple tool to use for non-specialists. Thus, we propose a mathematical model that allows assessment of the social, economic and environmental sustainability of a project. The aim is to provide a mathematical model for integrated sustainability assessment in any action, setting, and for any scale. We talk about a support tool for making decisions, political decisions (political in the sense of what emerges from both public and private fields) or any other type of decision that take into account the sustainability (we cannot think about any not to be taken) and this should be supported, of course, on a technical/scientific ground.

Keywords: Sustainable Development, social, economic or environmental impacts of a project in engineering degrees, Fuzzy Logic.

1 INTRODUCTION

Indeed, it seems that there is already some consensus at a worldwide level that the matter of the sustainability starts being an important part of the politic and strategic book of most countries [1, 2]. The Kyoto Protocol and the Summit of Bali, both promoted by the scientific reports of the Intergovernmental Panel on Climate Change (IPCC), prove this concern at a worldwide level; a concern that shows a worry even greater about the future of our planet and about the legacy that we are going to leave to our children.

The sustainable development is defined as “the development that satisfies needs of the present time without endangering the capacity of future generations to satisfy theirs”. The term “sustainable development” represents that balance between the satisfaction of present needs and the future ones, offering options of technological and social growth for reducing the risks meaning trends of topical increase.

The idea of sustainability can be analysed from three perspectives: environmental, social and economic [3]. These three points de view are basically coincident in their final aim, but they bring complementary visions to get it; because of that, in the confluence and balance between them is

where the sustainable development is reached. The environmental sustainability pursues a respectful growth with the environment. On the other hand, the social sustainability is based on the strategies of social justice in the world at the present time, with a view to the future generations. Finally, the economic sustainability deals with searching an economic development more balanced and stable at long-term, ie, the *Economy* intends to maximize the human well-being within the limitations of the capital and the existent technologies. The *Ecology* insists specially on preserving the integrity of the ecological subsystems with the purpose of securing the stability of the worldwide ecosystem, its units of account being physical, not monetary. Finally, the *Sociology* stresses that the human beings are the key agents, their sketch of social organisation being essential for finding feasible solutions in order to achieve the sustainable development. All things considered, the interaction among the economic, ecologic and social sustainability means arising the searching of a balance among the economic efficiency (the most favourable allocation), the social equity (the most favourable distribution) and the respect for the environment.

In this respect, we must assume the challenge and the opportunity to offer a model of sustainable development that makes compatible a dynamic of economic growth, as much as the increase of social well-being and an improvement of the environment. The evaluation of the natural resources as part of the economic output must be added and the exploitation of natural resources must be kept in a level as a minimum constant. Thus, the environmental sustainability could also be reached. But it is necessary to develop some indicators of the impact degree concerning the essence of the productive activity, in order to consider it in the economic scope. So, the combined output will be evaluated without considering only some economic factors that could bring to not sustainable situations, either from the environmental or from the social point of view.

An excellent way to show the basis of the fuzzy logic is through the applications. An innovative application of the fuzzy logic is the formalisation of a model that uses and determines it if a project is sustainable or just to a certain extent.

The Education for a Sustainable Development and the apprenticeship of the fuzzy logic are mixed in this survey. Sometimes, the indicators of the social, economic and environmental sustainability are provided in measurable magnitudes, absolutely objective, but sometimes, the great number of variables, the lack of knowledge, the insubstantiality and the incomplete or vague information recommend the use of the fuzzy logic techniques to help anybody to decide if a given project is sustainable. If it is not, what can be done to correct it and which impact can be rectified, in order to achieve anything.

Therefore, this paper has the intention to propose a systematic method for the evaluation of a project through a methodology that can be useful for the education and that includes appropriately two aspects: the sustainable development and the Fuzzy Logic.

2 THE DECADE OF EDUCATION FOR SUSTAINABLE DEVELOPMENT

The concept of sustainability means a new philosophy of the Economy because it introduces the environmental compatibility to consider the economic development. In this respect, the Universidad has to contribute to consolidate definitively the model of the Environmental Education. This is achieved with the development of the educational model, which will transform the reality and will be on all human beings service. The aim of this model will be the education of citizens, aware and involved with the global sustainability of the planet.

Thus, from the seventies, the Environmental Education has been proposing and consolidating an educational model, whose main elements are absolutely in tune with the paradigm of the sustainable development. This direction, which is more and more socially appreciated, has been improved with the Decision of the General Assembly of the United Nations to establish the period 2005-14 as the *Decade of Education for Sustainable Development.*

Therefore, the University has to contribute to the construction of societies, progressively more sustainable, offering an educational and checked model that guaranties a good education for the sustainable development of our societies [4]. The aim will be to introduce the student body to the concepts, tools and logic processes that are required for the comprehension of the present-day economic phenomena, producing involved and responsible behaviours. Thus, the students will be able to lead different projects that take the sustainable development into consideration and to identify different opportunities of management development, bound to economic and environmental actions.

They should have a global and integrated vision of the environmental problems, as well as the main concepts, approaches and different points of view regarding the sustainability, the knowledge of techniques and also innovative experiences of environmental management.

Besides, it is important to point out the work that the University can carry out about the training of professionals involved with the values of the sustainability. A survey of projects evaluation criteria is put forward, with a special emphasis on social and economic impacts of the projects in the local, regional or national development. Among such impacts, the environmental ones in its relationship with some general aims of sustainability can be found.

Moreover, the situation of the university degrees in engineering are within the process of European convergence of Highest Education and that can mean an improvement opportunity to provide a nearer focus to the present-day and real needs of these professionals.

3 A PROJECT AS AN ANSWER TO A SOCIAL REQUEST

A project appears as an answer to an idea that is searching the solution of a problem or as the way to make good use of a business opportunity. Many factors have an influence on the success or on the failure of a project. In general, we can point out that if the good or service produced is refused by the community, it means that the allocation of funds suffers from faults of diagnosis or of analyse, which make it unsuitable for the satisfaction expectancies of the population needs. Because of this, it is essential to evaluate a project to decide about the suitability to carry it out. The projects social evaluation tries to measure the true contribution of the projects for the economic growth of the country.

Traditionally, the papers and *projects evaluation* are made only from the economic point of view. However, it is not enough at present; that is why it is also so important to evaluate how the mentioned project brings an *economic* growth, apart from being able to represent a suitable social impact and not have aggressive or unsuitable consequences on the environment resources that are used, which in other words means: to evaluate if the project is sustainable [5, 6]. These evaluations must be analysed, about their natural resources (soil, flora and fauna), as well as about pollution of the air, water, soil, wastes and noise; about the natural value, the deterioration of the human customs or about the impact on people health…; as well as about the consideration of the economic aspects [7]. These assessments are management preventive instrument allowing that the sustainable politics could be fulfilled and incorporated soon into the development process and the decision-making.

The methodologies used are many. What we seek is to make a symbiosis between the methodology proposed in [8] and the handling techniques of the fuzzy information, since most of the concepts and the information used are *fuzzy* because of their vague nature. The value judgements, especially those with linguistic variables, are a very clear example of insubstantial information. For instance, the sentence “the quality of water is high” has different interpretations depending on who is the interlocutor and has different meanings.

The *impacts* characterization consists in the description of the identified impacts, considered significant or remarkable, according to an attributes series, although the consideration of an environment impact such as the alteration, modification or change of the environment quality made by a human activity is much known[1]. This classification is subjective and the knowledge can be incomplete. Therefore, the problems of scale and incertitude are going to stay present when it comes to determining the environmental effects and impacts, which are made due to a specific activity, especially in the case of the secondary ones or of those that are shown in the medium or long term.

In this paper, we are going to try to achieve an *evaluation of a social, economic and environmental impact*, ie, we try to identify, to predict, to value, to foresee or to rectify and to communicate the effects

[1] An environmental impact is identified by the effect of a simple action from an activity about an environmental factor. Both elements, action and factor, should remain explicit in the definition made of it. We can consider the following definitions included in [8]:

“Remarkable environmental effect: is the one that is significant, and which is considered as an environmental impact. It is the one that appears as a modification of the environment, of the natural resources, or of its fundamental processes of performance…”

“Minimum environmental effect (negligible): It is the one that can be proved that it is not remarkable.”

and the impacts made by works[2], distinguishing among the different options. The selection of social, economic and environmental factors and of works actions leads to identify the possible impacts. There are some indicators to evaluate those factors and actions.

As far as the process of an impact paper is concerned, we can distinguish four kinds of processes well differentiated: identification, valuation, prevention and communication. It is appropriate to underline the processes of identification and the valuation one.
The process of impacts *identification* will come from a list of environmental factors, with an allocation of weights for each factor, fixed in advance. Each kind of work has a list of actions (the usual ones for this kind of work). Each impact and each environmental effect comes through an impacted factor and through an impacting action.

The methodology can be summarised through the next steps [9]:

a. The description of the environment through a whole of economic, social and environmental factors affected by the project.
b. The description of the project through a whole of actions or activities.
c. The identification of the effects that each defined action has over each identified factor.
d. The difference between minimum effects and impacts.

The minimum effects are no longer evaluated, whereas the impacts must be valuated [10]. The remarkable effects or impacts are classified in its turn as compatible, moderate, strict and critical[3].

In the next step, as the impact *valuation* is concerned, there must be a differentiation between minimum effects and impacts. The valuation can be qualitative or quantitative.

In the *qualitative valuation*, some qualities of the impacts are valuated subjectively. As the environmental impact is concerned, the qualities normally used are those defined by the legislation. A numerical value, which is usually called *importance*, is then obtained.

This qualitative valuation is made through a linguistic description of their properties, such as low, middle, etc., to obtain a qualitative knowledge of the impact. The steps are:

1. The distinction of each impact through the assessment of its importance.
2. The global calculation of the project about the environment, using the important points obtained in the previous step.

In the *quantitative assessment*, the magnitude of the impact is measured. Some numerical indicators are used for it, providing a measure of the impact magnitude, which at first, is obtained in heterogeneous units. Through the transformation functions, these units turn in homogeneous or comparable units among different kinds of impact. This allows the obtention of a numerical valuation from the total impact made by the work, the project or the alternative, so that the total impact of the different alternatives can be compared; then, the one with a low negative impact is selected. However, it is important not only to establish the magnitude, but also the limit from which the provoked impact must impose some limitations to the action in the construction phase, as well as in the exploitation one.

Some of the aims when it comes to evaluating some projects are: to analyse the indicators, to arrange before-hand which are the ones that get the best measure of the impact, and the ecologic, social and economic consequences of certain values from the indicator, in addition of the limit values.

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[2] Four kinds of works can be selected: Communication pathways, which include in its turn, roads, railcars and motorways, and railways, usual and high-speed, barrages, rubbish dumps and incineration of solid wastes, and marinas.

[3] The following definitions included in [8] could be considered:

"Compatible environmental impact: it is the one whose recovery is immediate after the cessation of activities and no protecting or correcting practices are needed."

"Moderate environmental impact: it is the one whose recovery needs no protecting practices or correcting intensive ones. In this case, it is necessary some time to obtain the environmental conditions."

"Strict environmental impact: it is the one in which the recovery of the environmental conditions demands the fitting of protecting or correcting steps. That recovery needs a very long time."

"Critical environmental impact: It is the one whose magnitude is higher than the acceptable limit. A permanent loss of the environmental conditions quality takes place, without any possibility of a recovery, even with the adoption of some protecting or correcting steps."

4 THE IDENTIFICATION OF THE INDICATORS WHEN IT COMES TO EVALUATING SOME PROJECTS

For the execution of the economic valuation, it is necessary to use the criteria and classic indicators that are used in the *economic-financial valuation*, from the private point of view, ie, the topical Net Value, the Internal Rate of Return, the Profitability of the NPV (Net Present Value), the Deducted Recovery Period, and the Breakeven Point of the Investment. For the case of the risk valuation, some sensibility analyse will be made.

Besides, a financial valuation from the point of view of the investor will be made [11], in order to evaluate the effects of the financing.

Just as the economic indicators, the social indicators do not measure the sustainability by themselves, but they do it on the whole with the other indicators of a system. These indicators are used to evaluate the level of well-being in a society [12]. The access to the public health, the right to the culture, the demand of satisfying basic needs of people and in general, all those standards in connexion with the quality of life, as an integrant part of a totally sustainable development. In other words, the use of the Gross Domestic Product (GDP) can be fixed for the *social assessment*, which considers the National Income and not the Benefit, ie, it allows seeing how the project contributes to the increase of a country or of a region income. This is made by measuring the national income through an aggregated index, the added Net Actualised Value (NAV), which evaluates the main impact of the project in the economy. Other complementary qualitative criteria could be: the effect on the employment, on the income distribution by regions and by social groups and its impact on the balance of payments, which may have a great socioeconomic importance. The qualitative criteria cover all those valuations of the project effects that could not be quantified because of their size, lack of information or peculiarity.

As the *environmental impacts assessment* is concerned, the use of indicators is suggested, whenever possible, for the quantification of the effect that has already been fixed, in order to make more explicit the reached size by it. If we begin with this supposition, the necessary actions must be developed in order to avoid or to counteract the impact, if it is negative; or in order to seize the opportunity of the benefit if it is a positive impact.

The first step of this methodology consists in the identification of the physical, biologic, socioeconomic and cultural processes that may be affected by the suggested action. It is at this moment where the studies already made about the subject that inform about the “condition of the environment” are taken into account before the project starts. The main focusing is to unify the available information or to produce the necessary one within a specific area, in order to use it for the next phase of the impact assessment: the prediction of impacts. It is about to choose the effects that can really take place among the identified ones and that they deserve a special attention. This step requires the definition or the selection of the environmental impact indicators. A weighted cause and effect matrix is used for this purpose, which is structured around possible objectives of the projects on horizontal lines, whereas on the vertical columns, we can see the different sectors of the environment (soil, water, atmosphere, flora and fauna) as well as the economic environment, that in its turn, can be subdivided in components or in partial aspects of these sectors. There is a square in the intersection where the grades in which the objective affects the component are written.

The following concepts for the *evaluation of the importance* could be used:
Impact: Beneficial (B), Harmful (H).
Certitude: True (T), Probable (P).
Size: Smaller (1), Medium (2), Larger (3).
Reversibility: Temporal (T), Permanent (P).
Period: Immediate (I), Medium (M), Long (L).
Action: Yes (Y), No (N).

There are a lot of indicators that allow measuring the quality of waters, of air, of noise, of flora and of fauna. Many of them can be treated through the Fuzzy Logic to calculate its magnitude.

4.1 Why a system of indicators for the sustainability?

A system of indicators to assess if a project is sustainable or not is going to allow us:

- To make an effective monitoring about the application of plans of Economic, Social and Environmental Action.

- To evaluate the economic, social and environmental evolution with regard to the carried out actions.
- To favour the obtention of quick and effective information.
- To offer information to the citizens in an easy and instructive way.
- To determine the implication grade of the agents.
- To help to adopt political decisions with regard to the environment.
- To obtain a totalizing vision of the predominant interests in each municipality

5 THE FUZZY LOGIC AS A TOOL SECTION

The classic methodology has not the necessary tools to handle numerical and linguistic information at the same time. The fuzzy techniques are useful tools to approach a problem with vagueness, insubstantiality and lack of information, working properly with the linguistic and numerical variables in a combined way. Thus, it can be said: “Water is quite clear” or “a little cloudy” and then to work with those descriptions. The concepts of environmental quality (quality of the water, air, soil), economic, social or environmental impact have no dimension and are intangible and hardly quantifiable.

In that sense, a model that evaluates the sustainability of a project through the Fuzzy Logic as a tool is raised. On the other hand, the use of the applications in the teaching of the Fuzzy Sets Theory helps, with no doubt, to its study and better comprehension.

The Fuzzy Sets Theory or Fuzzy Sets is applied successfully to solve control problems. It was introduced for the first time by Lotfy Zadeh [13], who realised that it was usually no possible to get to useful solutions by using differential equations. That happened either by necessary simplifications or by many calculations that were essential. That is why he needed the use of new tools.

There are already methodologies that use Fuzzy Logic for the evaluation of environmental impacts in civil works, as well as for the evaluation of the pesticide utilisation in agriculture, the risk of groundwater pollution, the pollution of dumps and tips, and the impact of mining activities. For further details, please see the proposed program by [8].

All things considered, this paper proposes to follow the classic methodology of projects evaluation as the proposed in [8] and to use the Fuzzy Logic and the computer systems with words by changing the following aspects:

- To decide if an effect is an impact and the nature of it, which increases the firmness when it comes to form, to deduce and to take decisions about concepts of great subjectivity.
- To assess the importance: The knowledge is uncertain, vague and insubstantial. That is why the systems of fuzzy control may assess the importance of each impact. The linguistic variables that define the magnitude: extension, moment, reversibility, etc., are calculated and represented in the interval [0, 1]. The fuzzy wholes allow working with vague concepts and with numerical and vague values.
- To calculate the “best” indicators in order to measure the magnitude and to calculate its value.
- The scales of the variables used in the calculation of the magnitude are not homogeneous, which distorts the results and the weight of them in the importance value for each impact. The functions of transformation are fuzzy sets that allow transforming the measured magnitudes from heterogeneous to homogeneous. There is a subjectivity grade in the selection of the transformation functions that depends on the expert.
- The selection of different t-rules allows studying other possibilities to measure the value (qualitative and quantitative) of each impact, taking into account its standardised importance and its standardised magnitude.
- To classify each impact in “compatible, moderate and critical.”
- The functions of addition, which were studied in the Fuzzy Logic, allow obtaining the total impact f each alternative of a work, using the weights of the environmental factors.
- To develop a strategy to calculate the correcting steps that must be added to the project, assuming the previous assessment. All these impacts, whose assessment is considered that it is not within the acceptable limits, must be reduced through these steps. Now, the way to do it could be on the contrary. Coming from the final value that it could have, the necessary measures must be fixed to get it, using an approximate reasoning.

All this system of Fuzzy Logic, must be worked out through a computing system, due to the great number of involved variables. In this case, the system should use words for the computation. Therefore, it is advisable to use a fuzzy system based on rules. For this paper, the use of the *XFuzzy*

tool is thought out, because it has a suitable environment. The sustainability software in java can be tested at http:/www.fdi.ucm.es/profesor/lgarmend/SC/sostenibilidad.jar

6 CONCLUSIONS

We can see through this article the interest for the society of the sustainable projects evaluation teaching, the necessity of investigating a model that allow helping to make decisions about certain aspects of the social, economic or environmental impacts of the project, using the Fuzzy Logic. Besides, it must be an easy tool to be used for uninitiated persons.

Through this paper, we propose a mathematical model that allows assessment of the social, economic and environmental sustainability of a project. The aim is to provide a mathematical model for integrated sustainability assessment in any action, setting, and for any scale. We talk about a support tool for making decisions, political decisions (political in the sense of what emerges from both public and private fields) or any other type of decision that take into account the sustainability (we cannot think about any not to be taken) and this should be supported, of course, on a technical ground.

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